IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Japanese Application of

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Japanese Patent Application No.: 2002-122638

Japanese Patent Filing Date: April 24, 2002

for: "Secondary Battery and Storage Battery using the same"

VERIFICATION OF TRANSLATION

Honorable Commissioner of Patents and Trademarks

Washington, D.C. 20231

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(2) that he translated the above-identified Japanese Application from Japanese to English;

(3) that the attached English translation is a true and correct translation of the above-identified Japanese Application to the best of his knowledge and belief; and

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Date

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[Document Name] Specification

[Title of the Invention] SECONDARY BATTERY AND STORAGE BATTERY USING THE SAME

[Claims]

[Claim 1] A flat secondary battery provided with positive and negative electrode terminals for charge and discharge, formed to extend from an electric-power generating element, comprising:

a third terminal formed to extend directly from either the positive or negative electrode collector of said electric-power generating element, in addition to said positive and negative electrode terminals.

[Claim 2] The flat secondary battery according to claim 1, wherein said third terminal is formed to extend in the direction differing from the extending direction of said positive and negative electrodes for charge and discharge.

[Claim 3] The flat secondary battery according to claim 2, wherein the direction in which said third terminal extends is perpendicular to said extending direction of said positive and negative electrode terminals for charge and discharge.

[Claim 4] The flat secondary battery according to any one of claims 1 to 3, wherein said electric-power generating element is made up of anode elements and cathode elements alternately stacked with a separator sandwiched between each anode element and each cathode element.

[Claim 5] The flat secondary battery according to any one of claims 1 to 4, provided with a casing made of a laminate film.

[Claim 6] The flat secondary battery according to any one of claims 1 to 5, wherein a temperature detecting sensor is attached to said third terminal.

[Claim 7] The flat secondary battery according to any one of claims 1 to 5, wherein said third terminal is connected to a cell balancer circuit.

[Claim 8] A storage battery of a serial type using a plurality of flat secondary batteries according to any one of claims 1 to 7.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a secondary battery and a storage battery made up of the secondary batteries.

[0002]

[Prior Art]

Recently, demand has increased for a battery having medium/large storage capacity and comprised of secondary batteries. Specifically, demand has grown for such batteries that can be used in applications that include electric bicycles, electric bikes and electric motorcars, and attention has been focused on batteries having medium power in the 100W to 1000W class and also batteries having large power higher than 1000W.

[0003]

Conventionally, storage batteries having medium/large storage capacity and comprised of secondary batteries have been prevalent that are made up of a combination of many lead or nickel hydrogen cells and that are large in size, low in weight and volume density, and that are high in costs. However, since demand for storage batteries that have high power has been increasing, preference has arisen for storage batteries that are low in cost, have high weight and volume densities and that are capable of generating high power.

[0004]

In the meantime, a high-voltage lithium ion secondary battery, which serves as an elemental cell, has recently been realized, so that a secondary battery, in which a lightweight laminate film is used as a casing, has become prevalent. Therefore, there is a need to develop a small-sized and lightweight, high power storage battery that uses lightweight and high capacity lithium ion secondary batteries in which a lightweight laminate film is used as casing. In particular, since rapid charge/discharge characteristics as well as a high cycle life are required for a storage battery that is used for an automobile car, there are many problems that need to be quickly solved such as: the lowering of the internal resistance of the battery; a heat-generation problem due to rapid charging; problems in the control of cell balance in the interior of the battery; and the realization of a highly precise cycle-life prediction circuit.

[0005]

[Problem to Be Solved by the Invention]

In the conventional secondary battery, it has been common to perform measurement of the internal temperature by setting a temperature sensor either on a surface layer of the secondary battery or on the positive/negative electrode terminal. Mounting a temperature sensor on a surface layer of the secondary battery, however, makes it difficult to stack a plurality of secondary batteries when building up a storage battery, because the stack arrangement of flat secondary batteries each with a casing of laminate film has temperature sensors interposed between the secondary batteries, which could result in detecting average temperatures between the stacked secondary batteries, or which could cause damage to the secondary battery itself. In some cases, an arrangement has been adopted in which elastic material such as sponge sheets are sandwiched between the secondary batteries, in order to stack secondary batteries such that contact with the temperature sensors is avoided. The arrangement, however, entails not only lowering the weight and volume densities but also an increase in the number of processes of constructing the storage battery as well as an increase in component costs. Attaching a temperature sensor to an electrode terminal, on the other hand, requires an extra long terminal. Consequently, the construction of the storage battery requires a larger volume to accommodate the extra length of terminal, entailing the lowering of volume density. Furthermore, heat generated in the electrode terminal by the rapid charge/discharge operation causes the temperature sensor to detect the temperature of the electrode terminal rather than the temperature in the interior of the secondary battery. This has been responsible for the occurrence of the deviations in prediction of the battery life cycle of secondary batteries.

[0006]

Furthermore, it has been common practice in connecting a cell-balancer circuit or the like to a storage battery to draw out the lead wires for the cell-balancer circuit from charge/discharge electrode terminals of cells, when the cells are connected to one another, or to perform the connection between cells through a bus-bar and then draw out the lead wires for the cell-balancer circuit from the bus-bar. As a result, not only the installation of a control system such as a cell-balancer has been troublesome but also drawing out lead wires for a

cell-balancer circuit from the charge/discharge electrode terminals has prevented the electrode terminals from being shortened, entailing difficulty in lowering the internal resistance of the storage battery.

[0007]

It is an object of the present invention to achieve reduction of the internal resistance of a battery, to improve the accuracy in measuring temperature increases (or heat generation) in a secondary battery caused by a rapid charge/discharge operation of the battery, and to provide a secondary battery that allows easy construction of a storage battery and also to provide a storage battery that is made up of secondary batteries.

[0008]

[Means to Solve the Problem]

To achieve the above object, a third terminal is attached to extend from a sealed side of a laminate film of a conventional secondary battery. At this time, the third terminal is formed to extend directly from either the positive or negative electrode collector of an electric-power generating element included in the secondary battery in addition to the positive and negative electrode terminals that are included in the secondary battery and is formed to have the same potential as either the positive or negative electrode. In this way, it is possible to achieve the object just by adding one step to a process of fabricating a secondary battery without making any significant changes to the shape of the conventional secondary battery.

[0009]

Attaching a temperature sensor to the third terminal isolates the temperature sensor from the influence of heat generation in the positive and negative electrode terminals for charge and discharge, thereby enabling accurate detection of the internal temperature of the secondary battery, i.e., the temperature of the electric-power generating element.

[0010]

Furthermore, extending the third terminal in the direction perpendicular to the extension direction of the positive and negative electrode terminals facilitates the installation of the cell balancer circuit in constructing the battery. The reason for this is that, since the third terminal has the same potential as either the positive or negative electrode, the third

terminal can be used for connection with a control system such as a cell balancer, while performing inter-cell connection through individual direct connections of the positive electrode terminals and the negative electrode terminals of the secondary batteries, when the storage battery is being constructed.

[0011]

[Preferred Embodiments of the Invention]

The present invention is described below with reference to the drawings.

[0012]

Referring to Fig. 1(a), flat laminate-film secondary battery 1 of an embodiment of the present invention has third terminal 4 in addition to positive electrode terminal 2 and negative electrode terminal 3. Fig. 1(b) illustrates a conventional flat laminate-film secondary battery.

[0013]

Flat laminate-film secondary battery 1 of the present embodiment is constructed as described below. First, anode elements 5 and cathode elements 6 are alternately stacked with separators 7 interposed between them, thereby forming electric-power generating element 8 as shown in Fig. 2. Next, positive electrode terminal 2 and negative electrode terminal 3 are attached to uncoated sections (electrode collectors) 2a and 3a, free of active material, of anode elements 5 and cathode elements 6, respectively, as shown in Fig. 3. Next, third terminal 4 is directly connected to either uncoated sections 2a or 3a of anode element 5 or cathode element 6, respectively, as shown in Fig. 3. In Fig. 3, third terminal 4 is connected to uncoated section 2a of anode element 5. Third terminal 4 is attached in such a way that it does not contact positive electrode terminal 2. It is desirable to separate both the terminals as far as possible from each other in order to minimize the influence on third terminal 4 of heat generation possibly generated in positive electrode terminal 2 by rapid charge. Next, as shown in Fig. 4, electric-power generating element 8, in which positive and negative electrode terminals 2 and 3 and third terminal 4 are incorporated, is wrapped with laminate-film casing 9, which is sealed on the three sides by means of hot-melt fusion-bonding, and thereafter, non-aqueous electrolyte is injected into laminate-film casing 9, which is then completely sealed under reduced pressure, as in the conventional process of fabricating a laminate-film

secondary battery. Uncoated sections (electrode collectors) 2a, 3a, which are free of active material, of anode elements 5 and cathode elements 6, respectively, in electric-power generating element 8 may be arranged in opposed positions, as shown in Fig. 5.

[0014]

Detailed explanation will next be presented regarding an example of flat laminate-film secondary battery 1 of the present embodiment.

[0015]

In a first example of the present invention, anode elements 5 and cathode elements 6 are alternately stacked with separator 7 interposed between the anode and cathode elements and also with their electrode collectors (uncoated sections) 2a and 2b extended outwards from the same side, wherein each of the anode elements 5 comprises a sheet of aluminum foil of 20 μm in thickness to which is applied, on both faces, lithium-ion containing metal oxide such as lithium-manganese composite oxide that occludes/releases a lithium ion, approximately 70 μm thick; each of cathode elements 6 comprises a sheet of copper foil 15 μm thick to which is applied, on both faces, an approximately 50 μm-thick hard-carbon based cathode active material that occludes/releases a lithium ion; and separator 7 is a laminate separator made of a polypropylene film and a polyethylene film, which are sheets of porous insulator resin foils that are each 25 μm thick. A 100 μm-thick aluminum positive electrode terminal 2 and a 100 μm-thick nickel negative electrode terminal 3 are attached to electrode collectors (uncoated sections) 2a and 3a, respectively, of anode elements 5 and cathode elements 6 by means of ultrasonic welding. An aluminum terminal of 100 μm in thickness is next attached to positive electrode collector (uncoated sections) 2a by means of ultrasonic welding so as to extend outwards from collector 2a in the direction perpendicular to the direction of the extension of the positive/negative electrode terminal, to provide third terminal 4. While the ultrasonic welding is employed in the first example, any method capable of providing electrical conductivity, such as resistance welding or riveting, may be employed. Electric-power generating element 8 constructed in this way is next wrapped with an about 100 μm-thick laminate film made of aluminum foil 9, into which is injected the electrolyte produced by dissolving lithium phosphate hexafluoride with a non-aqueous solvent of

propylene carbonate and methyl ethyl carbonate; and the laminate film is then sealed by means of hot-melt fusion-bonding under a reduced pressure. The size of anode element 5 is 65 mm x 120 mm, the size of cathode element 6 is 70 mm x 125 mm, the size of separator 7 is 75 mm x 130 mm, the sizes of positive and negative electrodes 2, 3 are 40 mm x 10 mm, the size of the third terminal is 30 mm x 5 mm, the size of laminate film 9 for the casing is 95 mm x 160 mm and the width of the hot-melt fusion-bonding seal is 10 mm.

[0016]

In a second example, third terminal 4 made of nickel is formed extending from negative electrode collector 3a.

[0017]

In a third example, anode elements 5 and cathode elements 6 are alternately stacked sandwiching separator 7 there between so that electrode collector 2a and electrode collectors 3a (both being the uncoated sections) will be arranged opposite each other, and third terminal 4 of aluminum is formed extending from an end of electrode collector 2a of anode elements, perpendicularly to the direction in which positive and negative electrodes extend and further in the position sufficiently remote from positive electrode terminal 2, as shown in Fig. 5.

[0018]

In a fourth example, third terminal 4 of nickel is formed extending from an end of electrode collector (uncoated sections) 3a of cathode elements of electric-power generating element 8 in the position sufficiently remote from negative electrode terminal 3, wherein electric-power generating element 8 of the fourth example is the same as that of the third example.

[0019]

The constituent elements and the dimension of the constituent elements employed in the second to fourth examples are identical to those employed in the first example. These examples differ from one another only in that the directions in which the positive and negative electrodes extend differ and in that the potential applied to third terminal 4 differs. The flat laminate-film secondary batteries 1 disclosed in the first to fourth examples have 4.2 V (2 Ah) characteristics. The thickness is 4 mm, and the weight is 80 g.

[0020]

Table 1 represents the result of the measurements of the temperature in the interior of flat laminate-film secondary battery 1 disclosed in each of the first to fourth examples. The measurements were carried out as follows. The forced discharge of 50 A for 5 sec. was performed at an ambient temperature of 20℃, and then maximum attained temperatures were measured by means of thermocouples at positive and negative electrode terminals 2, 3, third terminal 4 and three places on the surface of the flat laminate-film secondary battery. Temperature rises (differences) with respect to the surface temperatures were determined at each site. Table 1 represents the temperature rises. Meanwhile, the temperatures of the positive and negative electrode terminals and the surface temperature are equivalent to the temperatures that are obtained based upon the method of measuring temperature in the interior of a flat laminate-film secondary battery.

[0021]

Table 1

	1st example	2nd example	3rd example	4th example
Temperature difference (℃) of positive electrode terminal	30.5	29.5	30.0	30.5
Temperature difference (℃) of negative electrode terminal	49.5	48.5	49.5	48.5
Temperature difference (℃) of third terminal (on the positive electrode collector)	3.5	—	0	—
Temperature difference (℃) of third terminal (on the negative electrode collector)	—	9.0	—	1.0

[0022]

As seen from Table 1, the temperature differences of the positive and negative

electrode terminals (the differences from the surface temperature of the cell) in the first and second examples are significantly large, approximately 30℃ at the positive electrode terminal and a little under 50℃ at the negative electrode terminal. The temperature differences in the third terminal, in contrast, are 3.5℃ on the positive electrode collector and 9.0℃ on the negative electrode collector, indicating that the temperature in the third terminal approximates the internal temperature of the cell with much higher accuracy than in the method of measurement according to prior art. In the third and fourth examples as well, the temperature differences of the positive and negative terminals (the differences from the surface temperature of the cell) are large, indicating approximately 30℃ at the positive electrode terminal and a little under 50℃ at the negative electrode terminal. The temperature differences of the third terminal, in contrast, are 0℃ on the positive electrode collector and 1.0℃ on the negative electrode collector, indicating that the third terminal exhibits temperature that is nearer the internal temperature of the cell than the temperatures of the third terminals in the first and second examples. It is thought that the reason for this is that the third terminals of the third and fourth examples are attached to the positions sufficiently remote from the positive and negative electrode terminals in order to be more insusceptible to the effect of heat generation in the positive and negative electrode terminals than in the cases of the first and second examples.

[0023]

The flat laminate-film secondary battery 1 provided with the third terminal of the present embodiment allows measurement of the internal temperature of a cell with a markedly higher accuracy than in the case of a conventional battery, in any of the first to fourth examples. In addition, since the temperature difference of the third terminal tends to exhibit a lower value on the positive electrode collector than on the negative electrode collector, the third terminal of the third example enables realizing a temperature value that is closest to the internal temperature of a cell.

[0024]

Fig. 6 illustrates an embodiment of the storage battery according to the present invention, which uses flat laminate-film secondary batteries 1 of the present embodiment.

The storage battery is structured such that ten flat laminate-film secondary batteries 1 are stacked with the positive and negative electrode terminals for charge/discharge being serially connected directly and further, with third terminals 4 being directed in the same direction. This structure is built up by stacking flat laminate-film secondary batteries 1 of the fourth example with the positive electrode terminals and the negative electrode terminals individually connected directly to make serial connections after connecting temperature-detecting sensors 10 and lead wires 11 for a cell balancer circuit to third terminals 4 of the flat laminate-film secondary batteries 1. As shown in Fig. 6, flat laminate-film secondary batteries 1 are stacked to realize the highest volumetric efficiency without providing any temperature-detecting sensor, an elastic element such as a sponge sheet, or the like between successive secondary batteries. Fig. 7 illustrates a storage battery constructed by connecting temperature-detecting sensor 10 and lead wires 11 for a cell balancer, which extend from the third terminals of flat laminate-film secondary batteries 1 built up as described above, to control circuit 12 and by wrapping the built-up flat laminate-film secondary batteries 1 with aluminum casing 13 that has a thickness of 2 mm.

[0025]

Referring to Fig. 8, there is illustrated a conventional storage battery for comparison. The storage battery was built up through the use of secondary batteries each of which had basically the same structure as the flat laminate-film secondary battery of the fourth example except that it lacked the third terminal. The conventional storage battery was constructed through the processes of attaching temperature-detecting sensor 10 to the central region of the surface of each secondary battery; connecting each lead wire 11 for a cell balancer circuit to the positive-electrode-terminal side of the positive and negative electrode terminals for charge and discharge; directly connecting the positive electrode terminals and the negative electrode terminals individually to form serial connections; and stacking the secondary batteries sandwiching elastic sponge boards (15g in weight, 2 mm x 70 mm x 120 mm in size) between successive secondary batteries. After stacking the secondary batteries in this way, each of temperature-detecting sensors 10 and each of lead wires 11 for the cell balancer circuit were connected to control circuit 12, and the whole battery system was wrapped with aluminum

casing 13 having a thickness of 2 mm, as in the example shown in Fig. 7. A conventional storage battery was produced in this way. As a result, the storage battery of the present embodiment exhibits a 35 % reduction in the volume ratio and a 10 % reduction in the weight ratio, enabling improvement in the weight and volume densities of the storage battery.

[0026]

In the present embodiment, the third terminals are formed extending from the sides of rectangular flat laminate-film secondary batteries 1, on which none of the positive and negative electrodes for charge and discharge are attached, in the direction perpendicular to the direction in which the positive and negative electrodes extend. The angle included between the extending directions of the third terminals and the positive and negative electrodes for charge and discharge need not necessarily be perpendicular, provided that it is feasible to install the cell balancer circuit and the like to be connected to the third terminals in a compact manner without necessitating superfluous space. Furthermore, the flat laminate-film secondary battery can have a shape other than a rectangle, provided that the shape allows the cell balancer circuit and the like to be connected in a compact manner without necessitating superfluous space.

[0027]

[Effect of the Invention]

As described above, the present invention enables an accurate measurement of the internal temperature of a flat laminate-film secondary battery, thereby allowing precise prediction of the cycle life of a battery, by forming, in addition to the positive and negative electrode terminals for charge and discharge, a third terminal, which has the same electric potential as either the positive or negative electrode terminal, to extend from the electric-power generating element and by measuring the temperature of the third terminal, as described above. Further, it is feasible to construct a more compact storage battery that secondary batteries are stacked.

[0028]

Since the third terminal has an electric potential and is also usable as a section to attach a lead wire for a cell balancer circuit as well, the wiring for control can easily be routed

in building-up a storage battery, resulting in facilitating the installation of a control system such as a cell balancer and the like. As a result, this enables simplifying the battery fabrication process, thereby reducing production cost.

[0029]

Furthermore, since it becomes unnecessary to attach temperature sensors and lead wires for a cell balancer circuit to the positive/negative electrode terminals, the electrode terminals can be shortened to optimum lengths, and the terminals can also be more easily connected directly to each other, whereby the internal resistance of the storage battery is reduced.

[Brief Description of the Drawing]

[Fig. 1]

Fig. 1(a) is a perspective view of a flat laminate-film secondary battery according to an embodiment of the present invention and Fig. 1(b) is a perspective view of a conventional flat laminate-film secondary battery.

[Fig. 2]

Fig. 2 is a diagram illustrating an internal structure of an electric-power generating element.

[Fig. 3]

Fig. 3 is a perspective view of a flat secondary battery.

[Fig. 4]

Fig. 4 is a diagram illustrating a structure of a flat laminate-film secondary battery.

[Fig. 5]

Fig. 5 is a perspective view of a flat secondary battery of an alternative embodiment.

[Fig. 6]

Fig. 6 is a diagram illustrating a structure of a storage battery using flat laminate-film secondary batteries according to an embodiment of the present invention.

[Fig. 7]

Fig. 7 is a diagram illustrating an example of constructing a storage battery using flat laminate-film secondary batteries.

[Fig. 8]

Fig. 8 is a diagram illustrating a structure of a storage battery using conventional flat laminate-film secondary batteries.

[Description of Numbers]

1: flat laminate-film secondary battery

2: positive electrode terminal

2a: uncoated section of anode element

3: negative electrode terminal

3a: uncoated section of cathode element

4: third terminal

5: anode element

6: cathode element

7: separator

8: electric-power generating element

9: laminate-film

10: temperature-detecting sensor

11: lead wire for cell balancer

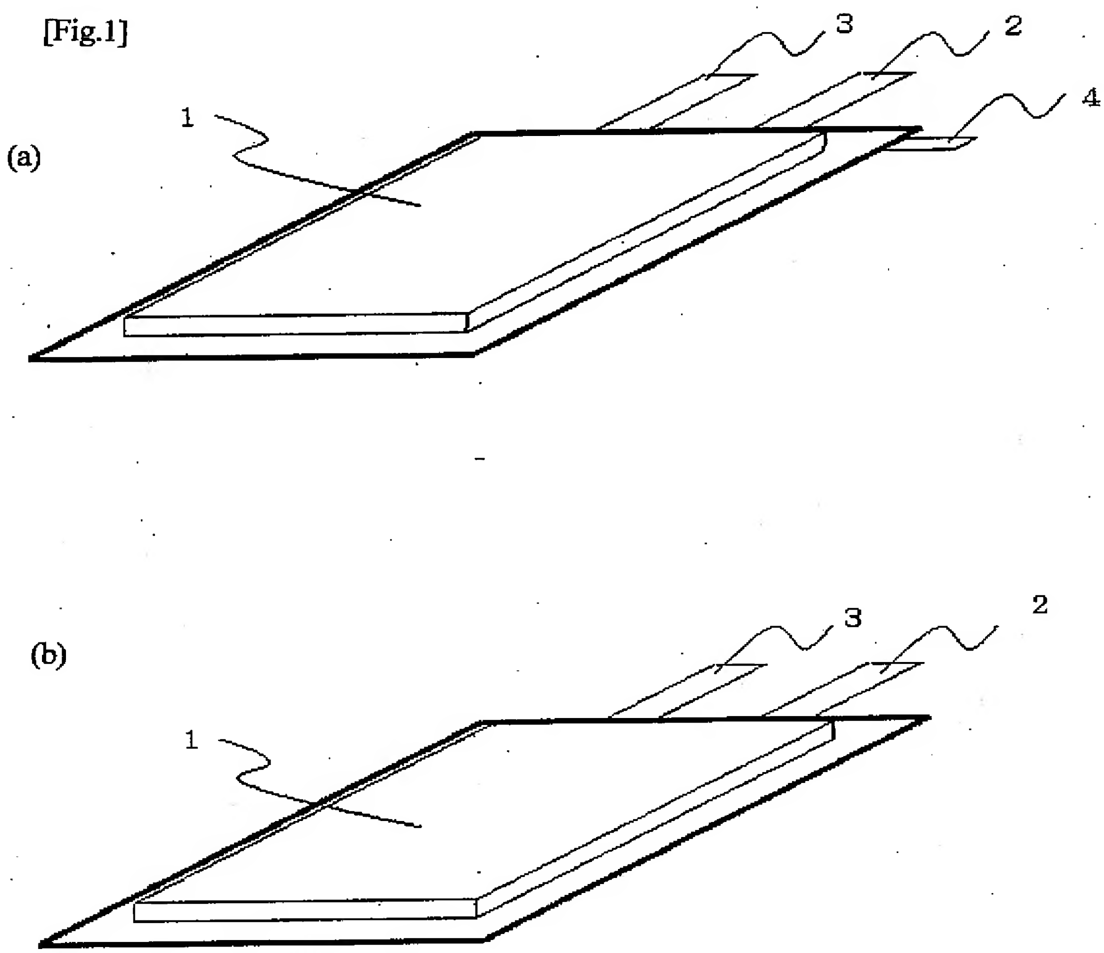
12: control circuit substrate

13: battery casing

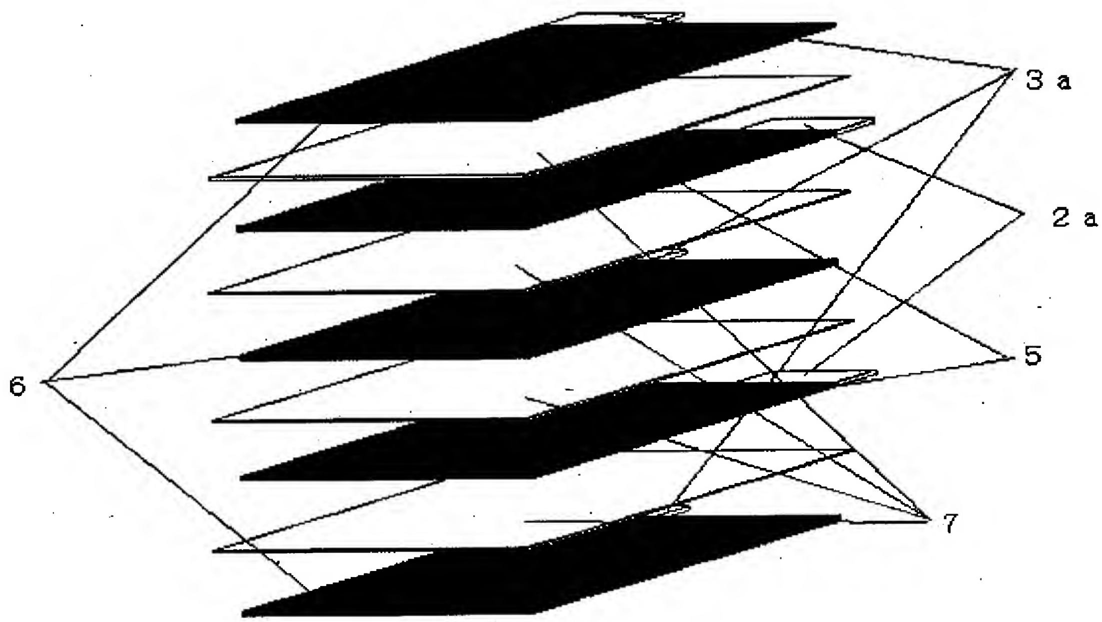
14: sponge-sheet (elastic material)

[Document Name] Drawings

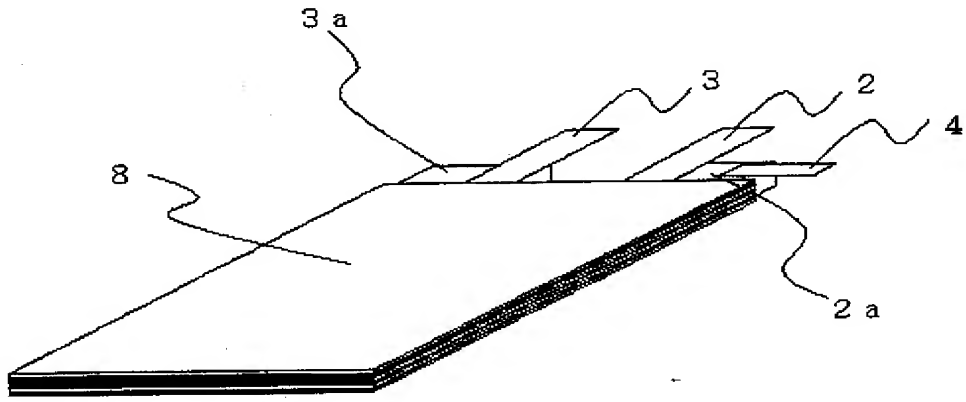
[Fig.1]



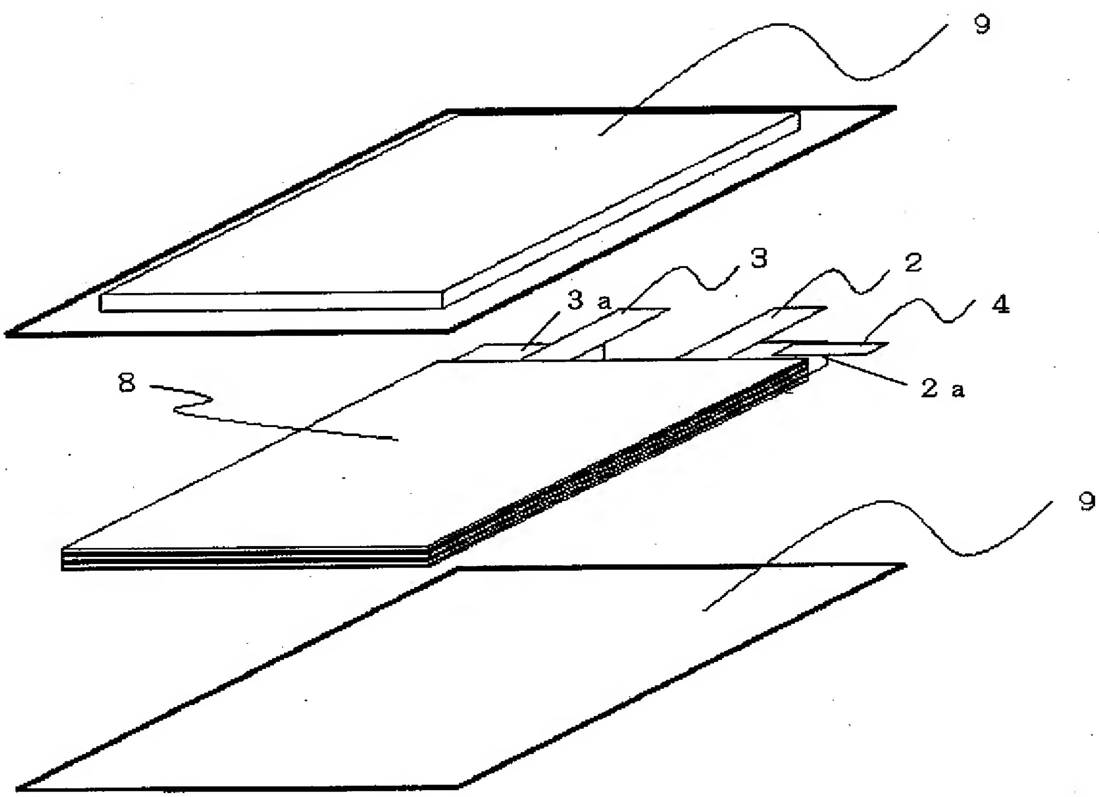
[Fig.2]



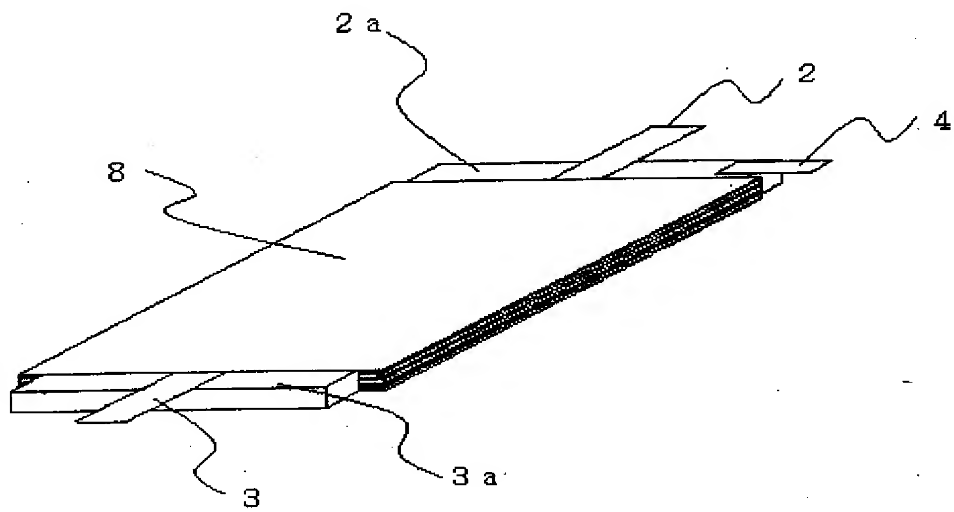
[Fig.3]



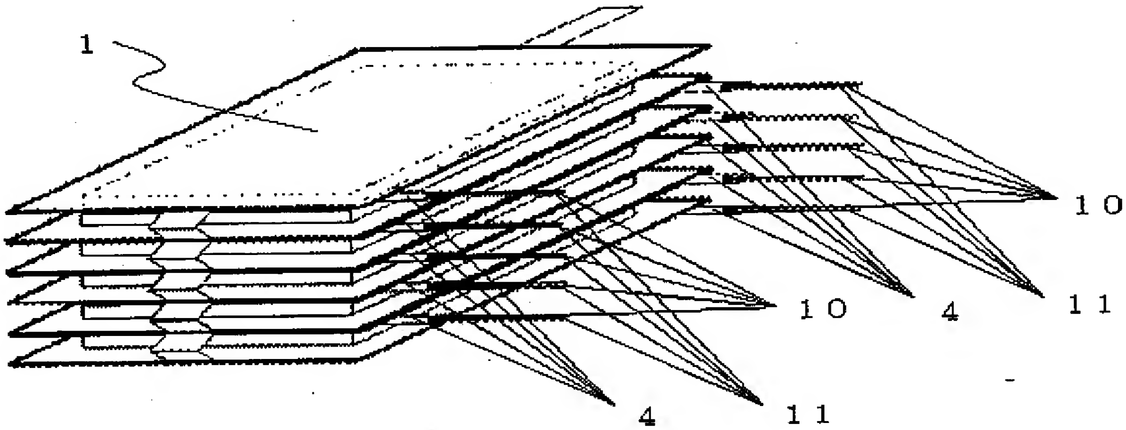
[Fig.4]



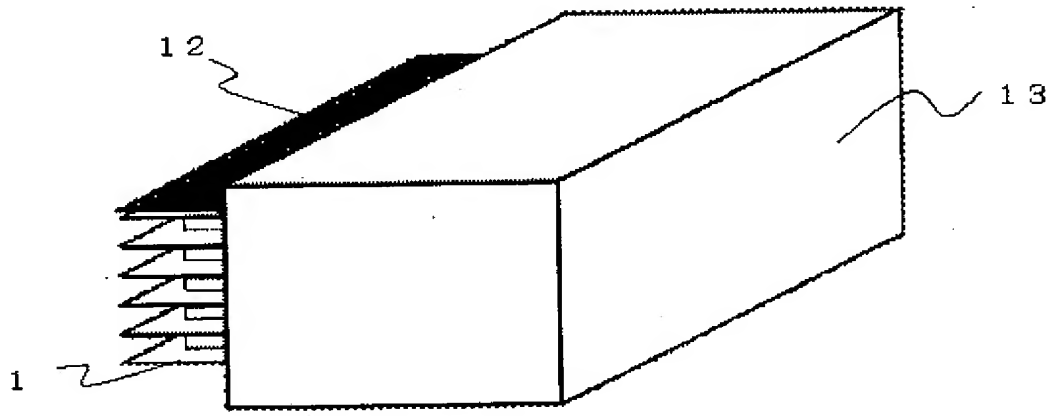
[Fig.5]



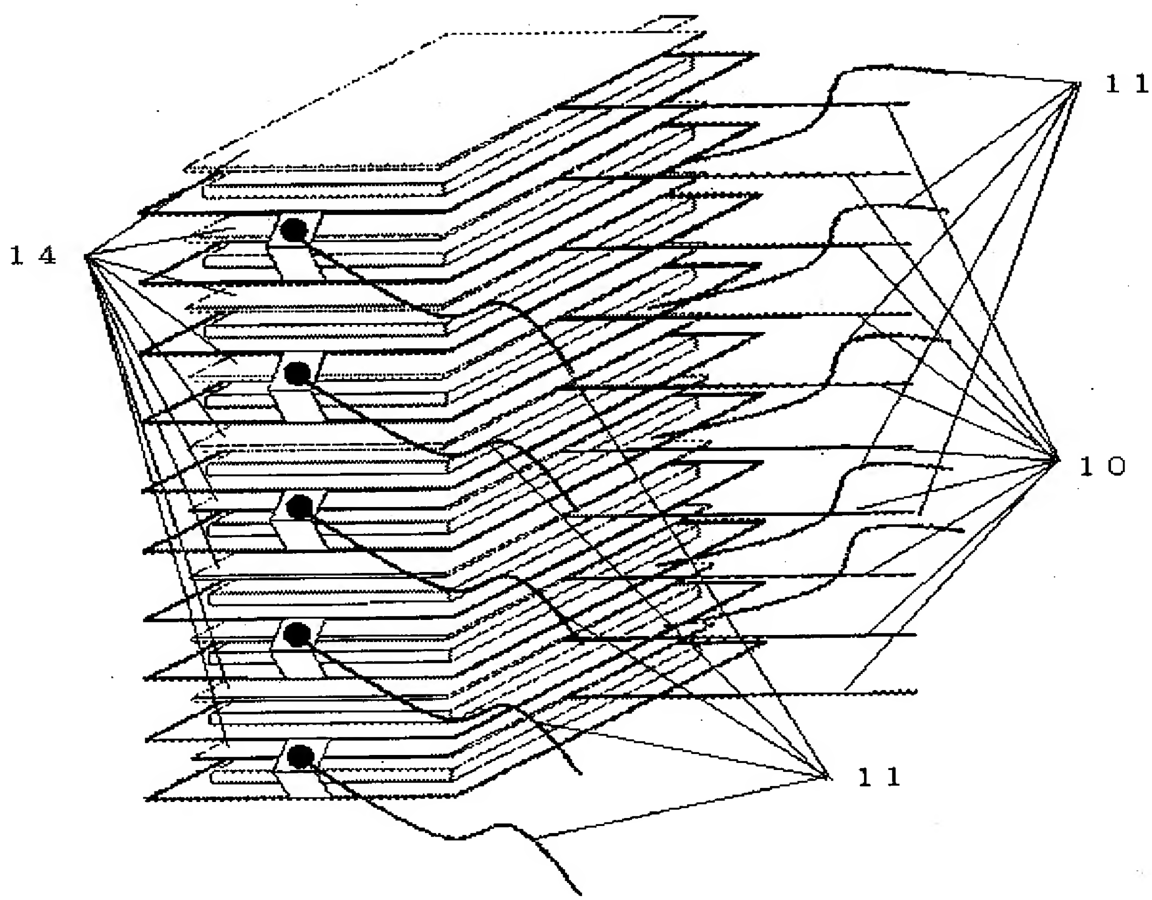
[Fig.6]



[Fig.7]



[Fig.8]



[Document Name] Abstract

[Abstract]

[Advantages] A secondary battery that enables accurate measurement of an increase (heat generation) in the temperature of the secondary battery generated by rapid charge/discharge, as well as enabling a reduction in the internal resistance of a storage battery and facilitating the construction of a storage battery, and also a storage battery that uses the secondary battery are provided.

[Constitution] In addition to positive and negative electrode terminals 2, 3 of a conventional flat laminate-film secondary battery (b), a third terminal is attached perpendicularly to them, wherein third terminal 4 is connected to electrode collector 2, 3 of electric-power generating element (a) that makes up the secondary battery 1 and is adapted to have the same potential as the potential of either the positive or negative electrode collectors 2a, 3a. The internal temperature of secondary battery 1 is obtained by temperature measurement of third terminal 4, and a cell balancer circuit and the like are connected to third terminal 4. The construction of the storage battery is performed by directly connecting positive and negative electrode terminals 2, 3 in series.

[Selected Figure of the Drawings] Fig. 1